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The goal of this project was to assemble an integrated system of digital audio archival and retrieval with which the Macaulay Library at Cornell University could preserve the large body of marine animal sounds collected by researchers funded by the US Navy, NOAA, and other government funding agencies over the last three decades, and make this collection available to a wide spectrum of users over the Internet. This system has been successfully assembled and as of this report, a total of 307 hours (1870 specimens) of original recordings covering 31 species of cetaceans, 9 pinnipeds, and 202 species of fish have been digitized and prepared in formats suitable for Internet distribution. The Internet distribution hardware is also now in place and public availability awaits only the completion of the relevant search and delivery software. The latter is currently being written with concurrent funding from NOPP and NSF awards. Internet access to the digital marine sound collection is scheduled for Spring 2005.

15. SUBJECT TERMS

marine mammals, internet collections, animal sound recordings, digital audio archival

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FINAL REPORT

GRANT #: N00014-02-1-0620

PRINCIPAL INVESTIGATOR: Dr. Jack W. Bradbury

INSTITUTION: Cornell University

GRANT TITLE: A Digital Audio Storage and Web Access System

AWARD PERIOD: 1 May 2002 - 14 May 2003

OBJECTIVE: To assemble an integrated system of digital audio archival and retrieval with which the Macaulay Library at Cornell University could preserve the large body of marine animal sounds collected by researchers funded by the US Navy, NOAA, and other government funding agencies over the last three decades, and make this collection available to a wide spectrum of users over the Internet

APPROACH: The overall task can be divided into sub-tasks for which specific hardware solutions are then sought. These sub-tasks are: a) acquisition and tracking of original recordings and "daughter" copies, b) high resolution digital archival, c) network transport between archival workstations and storage media, d) authoring of DVDs as the long-term hard copy storage medium, e) DVD analysis to ensure that the archive is error-free, and f) transcoding for multiple types of usage and delivery over the Internet. The challenge is to identify solutions for each sub-task that are long-term integratable with the tools sought for the other sub-tasks. The selection among alternatives for each tool set is also affected by the software environment in which they will operate which also must be integratable throughout the system.

ACCOMPLISHMENTS: Taking each sub-task in turn:

a) Acquisition & Tracking: Accessions' tasks were resolved with a bar-coding system connected to a hard-label printer, bar reader, and central tracking server that integrates directly with the overall archive (Oracle) metadata. This ensures that the original hard copy recording and all digital "daughter" copies are permanently linked through the master database.

b) Digital Archival: Three identical audio archival studios were assembled and integrated. Each includes the following equipment: Sonic Solutions high-density digital audio workstations w/relevant Macintosh host computers and

Sony display monitors; Prism ADA-8AES A/D & D/A converters; Z-Systems 3SRC sample-rate converters; Z-Systems Q2 digital parametric equalizers w/mid-side encoding/decoding; Sony PCM-500 R-DAT recorders; and Event 20/20BAS monitor speakers. Tascam CD-RW2000 recorders generate one-off discs for client review and the Tascam CD-D4000 1:1 CD duplicators are used to create in-house safety copies of client reference discs. Bittree patch-bays provide the necessary signal routing. Additionally, a Cole-Parmer electronic desiccator and vacuum chamber system were purchased to stabilize deteriorating magnetic tape stocks prior to the digitization process.

c) Network Transport: High-speed, Rorke Data Inc. FibreChannel networking infrastructure was created including 1.75 terabytes of spinning disc, host-bus adapters, Vixel switches, APC UPS battery backup system and related management hardware/software. This equipment handles all marine mammal audio archival ingest, work-in-progress editing, and DVD authoring. It is also seamlessly integrated into the pre-existing Macaulay Library studio network system. This integration provides the most efficient workflow, allows studio interchangeability in case of hardware failures, and allows archivists to easily cross check each other's work for quality assurance.

d) DVD Authoring: This sub-task is handled by three (two primary, one backup) Pioneer DVD writers (precision authoring versions), and two Sonic Solutions OneClick DVD authoring software packages. To maintain absolute precision we purchased a Lucid Audio high-resolution digital system clock that locks all studios and authoring systems together on a common time-base. To handle the pre-authoring of multi-channel or high sample-rate (192kHz/24-bit) materials we purchased a Genex 8500 digital recorder and dCS precision converters. A Benchmark Media DAC-1 D/A converter is used in the authoring Q/C stage.

e) DVD Analysis: A AudioDev model CATS DVD Pro-R/RW analyzer was acquired to provide the highest level of quality control possible. With this device we are able to test and evaluate all of our DVD discs (blank & written). This system greatly reduces the amount of engineering time spent on trouble shooting problem disc issues. It also allows us to evaluate blank stock so we use only the best discs, and it reduces the amount of hours on our expensive recorders thereby saving valuable laser hours. The longevity of any DVD digital archive rests solely on the integrity of the DVD discs. By randomly re-testing discs over time and comparing with original test results we can monitor the health of the digital media. Any signs of

premature failure can be readily identified by the CATS system and new discs can be generated.

f) **Storage and Delivery System:** The plan in the original proposal was to augment our pre-existing EMC Enterprise storage system by about 3 terabytes of storage to house and distribute the marine animal sound collection. Over the term of the award, storage technologies and delivery strategies changed radically, and the volume of material found to be suitable for the archive grew enormously. We carefully monitored these changes, and through frugal negotiations and corporate partnering, we were able to leverage the available funds to purchase considerably more storage capacity thereby resolving the problem of how to store the increased volume of recorded materials. In the end, the equipment purchased for this system includes 9-Apple X-Serve RAID devices, and 9-Apple X-Servers, high-speed Vixel FibreChannel switches. It also includes upgrading our EMC Symetrix and Celerra systems to the newer, lower operating cost Clarion system, an APC, UPS battery backup system, application development and system management computers and all relevant management and transcoding software.

CONCLUSIONS: The Macaulay Library now has 3 fully equipped digital studios for audio archiving of marine animal recordings, lossless transport between the studios and authoring workstations, permanent storage of the high-resolution digital copies on pre- and post-cutting DVDs, transcoding to resolutions suitable for public use, and integrated storage and delivery hardware for connections to the Internet. The archival studios have already digitized 307 hours (1870 specimens) of marine animal recordings including data on 8 mysticete cetaceans, 24 odontocetes, 8 pinnipeds, 1 sirenian, and 202 species of fish. The software necessary for Internet search of the collection and subsequent access is currently being written with support from NOPP and NSF awards. The marine animal sound library is scheduled to go online in Spring 2005.

SIGNIFICANCE: This project will make available to researchers, the military, educators and students, the media, and the general public the world's largest collection of marine animal sounds and the only one that can be browsed and sampled directly on the Internet.

PATENT INFORMATION: None

AWARD INFORMATION: None

PUBLICATIONS AND ABSTRACTS:

1. Grotke, R.W. (2004). Digitizing the world's largest collection of natural sounds: key factors to consider when transferring analog-based audio materials to digital formats. RLG Diginews 8:1-8 (also available online at: http://www.rlg.org/preserv/diginews/v8_n1_feature.html)